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[Abstract of the Disclosure]

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[Abstract]

The present invention relates to a reflective-transmissive complex
type thin film transistor liquid crystal display in which liquid crystal films of
a transmissive region and a reflective region are different in thickness so as
10 to adjust a phase of polarized light at each of pixel portions constituting a
screen.

Accordingly, the phase of the polarized light is adjusted to increase
the amount of emitted light in one region while the amount of the emitted
light is fixed at another region and to enhance entire screen luminance and
15 contrast.

[Typical Figure]

FIG. 4

[Specification]

5 [Title of the Invention]

A REFLECTIVE-TRANSMISSIVE COMPLEX TYPE TFT LCD

[Brief Description of the Drawings]

10 FIG. 1 is a cross-sectional view of a pixel portion of a TFT side substrate according to an example of a conventional reflective-transmissive complex type TFT LCD.

FIG. 2 is a concept diagram showing a cross structure of a liquid crystal display panel and a phase shift of light at a reflective region and a
15 transmissive region in order to explain conventional problems.

FIG. 3 is a concept diagram showing a cross structure of a liquid crystal display panel and a phase shift of light at a reflective region and a transmissive region in order to explain conventional problems.

FIG. 4 through FIG. 7 are cross-sectional views showing another
20 embodiments of the present invention.

*Explanation of the signs that are the main part of the drawings

| | |
|-------------------------------|----------------------------------|
| 10 : substrate | 11 : gate |
| 13 : gate insulating layer | 15, 17 : amorphous silicon layer |
| 25 19 : drain electrode | 21 : transparent electrode |
| 23 : organic insulating layer | 25 : reflective layer |
| 27 : transmissive region | 29 : insulating layer |

[Detailed Description of the Invention]

[Object of the Invention]

[Field of the Invention and Prior Art related to the Invention]

The present invention relates to a reflective-transmissive complex type thin film transistor liquid crystal display and, more particularly, to a reflective-transmissive complex type thin film transistor liquid crystal display in which additional reflective and transmissive layers constituting a pixel electrode are formed to occupy a predetermined region of a pixel.

With advance in information society, information display devices are very significant. Of these information display devices, an LCD is a rapidly developed field in recent years. Particularly, a TFT-LCD using a thin film transistor to control pixels has intrinsic advantages such as lightness, thinness, and low power consumption as well as satisfaction for user's demands such as high resolution, high operation speed, and colorization. For these reasons, the TFT-LCD has been widely used.

Forming the pixel portion TFT of a typical LCD is simply explained with reference to an example of a bottom gate type amorphous silicon type TFT-LCD. A single layer of aluminum or chrome or a multiple layer is stacked on a glass substrate. A patterning work including a photolithographic process and an etching process is used to form a gate pattern having a gate line and a pad (first mask). A gate insulating layer, an amorphous silicon layer to form an active region such as a channel and source/drain, an impurity-doped amorphous silicon layer for an ohmic contact are sequentially stacked on the gate pattern. Using a photomask corresponding to the active region, this triple layer is patterned (second mask).

Under this state, a metal layer for forming source and drain electrodes is stacked and a source/drain electrode and a data line are formed by means of a mask technique (third mask). Alternatively, after the triple layer is stacked and the metal layer is stacked prior to formation of an active

region pattern, the source and drain electrodes are patterned and the ohmic contact layer and a top surface of the amorphous silicon layer are removed to form a channel, which can be replaced with the second and third mask processes (4-piece mask process).

5 A protection layer made of a conductive substance is stacked on a MOSFET (metal oxide silicon field effect transistor) basic electrode structure of the source, the gate, and the drain which are formed through the above procedure. Afterwards, a patterning process is performed to form a contact hole for connection to an external signal input pad or a pixel
10 electrode (fourth mask). The protection layer is generally made of silicon oxide or silicon nitride but may be made of thick organic material.

A patterning process is performed again to form a pixel electrode on the protection layer. In case of a reflective LCD, the pixel electrode is formed on an upper portion of a pixel by stacking aluminum using a
15 sputtering technique and a photolithographic process and an etching process, and is electrically connected to a source of a transistor through a contact. The pixel electrode acts as a reflective layer. Since a light reaches user's eyes through the pixel electrode, the pixel electrode of a backlight or transmissive LCD is made of transparent ITO (indium tin oxide), IZO
20 (indium zinc oxide), and so forth (fifth mask).

Besides the above basic 5-piece mask process, a method of fabricating a liquid crystal display is variable with the number of process masks and the structure of a transistor.

As a simple TN (twisted nematic) type liquid crystal display, a
25 reflective LCD is mainly used in an apparatus for minimizing power consumption such as a timepiece or a calculator in early stage. However, a transmissive LCD is mainly used in a notebook computer, particularly, a TFT-LCD requiring a wide screen and high quality. Sharp Inc. already introduced a reflective-transmissive complex type LCD which can secure a

visibility fitted for the use environment even if a peripheral brightness is varied.

In the introduced reflective-transmissive complex type thin film transistor LCD, a pixel electrode pattern is formed as a transparent electrode layer by means of a sputtering manner when a pixel electrode is formed on an organic insulating layer 23 while an electrode of a conventional TFT side substrate 10 is formed. After a metal layer (i.e., reflective layer) made of aluminum or chrome is formed thereon by means of the sputtering manner, a desired reflective layer pattern is formed by means of a mask process (i.e., a photolithographic process and an etching process). As a result, a pixel electrode outside region, a transparent region, and a reflective region are formed. In the pixel electrode outside region, the pixel electrode including the reflective layer 25 or the transparent electrode 21 does not remain on the organic insulating layer 23. In the transmissive region 27, only the transparent electrode 21 remains. In the reflective region, the reflective layer 25 remains on the transparent electrode 21. The transparent region 27 is a window conceptively and thus may be called a transparent window. FIG. 1 is a cross-sectional view of a TFT side substrate at a pixel portion according to an example of the conventional reflective-transmissive complex type TFT-LCD. Here the transparent electrode 21 is formed prior to formation of the organic insulating layer 23.

In a panel of the conventional reflective-transmissive complex type TFT-LCD, liquid crystal layers or cell gaps of transmissive and reflective regions of each pixel are substantially equal in thickness to each other. However, in view of a light phase at a TN type liquid crystal cell adopted in most TFT-LCD, it is impossible to simultaneously obtain a maximal luminance at a transparent mode and a reflective mode in case that the liquid crystal layers are equal in thickness to each other.

FIG. 2 is a concept diagram showing a cross structure of a liquid

crystal display panel and a phase shift of light at a reflective region and a transmissive region in order to explain conventional problems. In a reflective region, a light does not pass under a reflective layer 41. Therefore, a backlight or a phase different plate is meaningless and will not be described in further detail. A polarization plate 31 of a panel upper portion (front side) is disposed to pass only light elements having a phase vibrating left and right in this figure. A lower side (rear side) polarization plate 33 of a transmissive region is installed to pass light elements having a phase vertically vibrating to the figure. Pivots of phase difference plates 35 and 37 are perpendicular to each other in an internal side of the polarization plate. The liquid crystal layer 39 controls property and thickness of the material, so that a phase shift on a light passage becomes $\lambda/4$. Further, liquid crystal layers in both regions are substantially equal in thickness to each other.

In ON state where a voltage is commonly applied to panel upper and lower electrodes in the two regions, there is no light from the panel. In this case, since the liquid crystal layer is arranged to be not distorted but parallel, the phase is not shifted. Accordingly, the thickness of the liquid crystal layer is not significant. However, in OFF state where a voltage is not applied to the panel upper and lower electrodes, the light running from the panel to the outside must be in a phase where it is rotated counter-clockwise shortly before passing the upper phase difference plate ($\lambda/4$ plate) so as to maximize the amount of the light from the panel. On the other hand, the phase shift of the light passing a conventionally designed liquid crystal layer is $\lambda/4$ (45°). To maximize the amount of the emitted light, the light starting to run from the pixel electrode (e.g., the light reflected from a reflective layer in a reflective mode) must be present at a phase where it vertically vibrates to the figure.

However, as shown in FIG. 2, if the polarization plate and the phase difference plate are arranged on a structure of a polarization plate 31, a

phase difference plate 35, a liquid crystal layer 39, and a (-) phase difference plate 37, and a polarization plate 33 which are associated with polarization, analysis, and phase shift of the light from the front side, the light starting to run from the pixel electrode, i.e., the light passing the transparent electrode 43 is in the phase where it is rotated clockwise in order to avoid an emitted light of the panel. As a result, in the case that the thickness of the liquid crystal layer is conventionally designed, if the phase shift of the passing light is a thickness corresponding to $\lambda/4$, it has a vertically rotated phase, not a phase where it is rotated counter-clockwise shortly before passing the upper phase difference plate and it has a phase rotated counter-clockwise before passing the polarization plate. Thus, the amount of the emitted light has a phase difference of $\lambda/4$ (45°) with respect to a polarized light passing the polarization plate without loss, so that the light amount is reduced to be half of the maximal amount.

Particularly, there is a need for complementing means for avoiding loss of light amount in view of the fact that the reflective-transmissive TFT-LCD has an acute problem associated with the luminance.

[Technical Object of the Invention]

Therefore, it is an object of the invention to provide a new reflective-transmissive complex type which can obtain a maximal luminance by avoiding the foregoing problem that a conventional reflective-transmissive complex type TFT-LCD cannot obtain the maximal luminance at both a transmissive region and a reflective region.

[Construction of the Invention]

According to the present invention, a reflective-transmissive complex type thin film transistor liquid crystal display device comprises a reflection region where a reflection layer exists at a partial region in a pixel

electrode of each pixel portion of a liquid crystal panel constituting a screen and a transmission region where a transparent layer including a transparent electrode is formed. A liquid crystal layer in the transmission region is different in thickness from a liquid crystal layer in the reflection region.

5 A polarization plate and a phase difference plate whose pivots are perpendicular to each other are formed front and rear substrates in the liquid crystal panel, the thickness of the liquid crystal layer in the reflection region is set such that a phase shift of the light passing by liquid crystal is $\lambda/4$, and the thickness of the liquid crystal layer in the transmission layer is $\lambda/2$ of the
10 phase shift.

An insulating layer formed between a thin film transistor drain electrode of the pixel portion and the reflection layer of the pixel electrode is made of photoresist transparent organic insulating material and is removed in the transmission region by means of the different thickness method.

15 The present invention will now be described more fully hereinafter with reference to attached drawings, wherein the same numerals denote the same components.

FIG. 4 is cross-sectional view showing an embodiment of the present invention. In a bottom gate 11 type transistor structure, a drain electrode 19
20 is widely formed and an organic insulating layer 23 is thickly stacked. A pixel electrode is formed thereon and is electrically connected to the drain electrode through a contact hole formed at the organic insulating layer. The pixel electrode a multiple layer including a transparent electrode layer 21 and an aluminum reflection layer 25 with another insulating layer 29
25 interposed therebetween. The insulating layer 29 is made of silicon nitride. The insulating layer 29 serves to prevent the problems that results from an aluminum oxide layer when aluminum is in direct contact with an ITO transparent electrode layer. The reflection layer 25 and the transparent electrode layer 21 are contact with the drain electrode 19 at a contact. The

thickness of an aluminum-containing reflection electrode layer and a transparent electrode layer is relatively smaller than the width of the drain electrode 19 exposed through a contact window. Therefore, just as a contact window is formed at an insulating layer when a patterning process is conducted at a layer stacked in advance among the two electrodes constituting a pixel electrode, so the layer is partially removed to make a window and to form an insulating layer 29 only thereon. In the contact region, if a central portion of the insulating layer 29 is partially removed and the reflection layer 25 is stacked, a connection structure with each pixel electrode layer and a drain region constituting a pixel electrode without an additional exposure and etching processes. In the transmissive region where the reflection layer 25 is removed, the organic insulating layer 23 is removed to be concave at the same when a contact hole is formed. That is, the transmissive region where only the transparent electrode layer remains from the pixel electrode is structured to increase the amount of the light passing the transmissive region because the liquid crystal layer becomes thick as much as the organic insulating layer 23 is removed.

FIG. 5 is a cross-sectional view of a pixel portion according to another embodiment of the present invention. As compared to the case of FIG. 4, except the organic insulating layer 23 and a part of other insulating layers, most layers are removed at the transmissive region. The structure of the pixel electrode has a transmissive electrode 21 directly connected to a drain electrode, the organic insulating layer 23 disposed thereon, and a reflection layer 25 stacked on an entire surface of the structure where the thickness of the organic insulating layer 23 disposed on the drain electrode and the thickness of the organic insulating layer 23 disposed on the transmissive region are mostly removed. At this time, a reflection layer is removed at the transmissive region. The stacked reflection layer 25 is made of aluminum. As a result, the reflection layer 25 stacked on the drain

electrode 19 forms the drain electrode 19 and a contact and the reflection layer is removed at the transmissive region to make a transparent electrode 21 and a partial thickness of the organic insulating layer 23 remain. Thus, most light of backlight passes.

5 FIG. 6 shows the complement for the foregoing disadvantages explained in FIG. 5. In FIG. 5, when the insulating layer on the drain electrode and the insulating layer in the transmissive region are removed, all layers on the drain electrode are removed and all layers on the transmissive region remain, which is very difficult. Accordingly, prior to formation of the drain electrode 19 and the organic insulating layer 23, a pixel electrode is formed which is coupled to the drain electrode 19 and includes the transparent electrode 21. Another insulating layer 29 is formed on the transparent electrode 21 to form a contact. Even when the overlying organic insulating layer 19 is completely removed, the insulating layer 29 formed on the transparent electrode 21 is not removed to prevent an aluminum layer and a transparent electrode layer, which constitutes the reflection layer, from contacting with each other.

10 FIG. 7 is similar in concept to FIG. 6, in which a different insulating layer 29 is formed on a transparent electrode 21 and, instead of patterning, a metal layer 28 is used to act as a buffer between the transparent electrode 21 and a reflection layer 25 made of aluminum. In FIG. 7, there is a modification that while a source/drain electrode is formed by modifying a procedure of forming a transparent electrode layer coupled to a drain electrode, the source/drain electrode may be monolithically formed with a transparent electrode layer of a pixel electrode by means of the transparent electrode. Alternatively, the source/drain electrode is made of only the transparent electrode layer. In case that a data line is formed, a conductive rate is lowered. For that reason, a source/drain electrode is made of the transparent electrode and chrome which are sequentially stacked. Of course,

in order to explain a characteristic structure of the present invention, an insulating layer of a transparent region is removed when a contact window is formed and after a reflection layer made of aluminum-containing metal is stacked, aluminum metal is removed for making a transparent window at the transmissive region. At this time, an opaque metal layer having an etch selectivity with respect to the aluminum-containing metal such as chrome is removed to form a transparent region.

In this embodiment, aluminum is mainly exemplarily explained but a high reflectivity and conductivity material such as silver may be used.

Further, the transparent electrode is typically made of one material selected from an indium oxide group, e.g., ITO (indium tin oxide) or IZO (indium zinc oxide) which is attractive as a candidate for ITO in recent years.

In the case where the insulating layer disposed between the drain electrode and the reflection electrode is made of inorganic material, it is likely to be a thin film like other films used when a thin film transistor is formed. Therefore, in view of the fact that it may be very thin as compared to the thickness of a liquid crystal layer, a relatively thick organic insulating layer is used. The organic insulating layer is typically made of a photoresist transparent organic material such as polyimide which makes it possible to perform a patterning work only means of a photolithographic process without an etching process.

In the reflective-transmissive complex type transistor liquid crystal display device, the stack order of a reflection electrode layer and a transmission electrode layer, which constitute a pixel electrode, is preferably dependent on convenience of a fabricating process according to a reflection efficiency and an etching rate between two electrode layers. Particularly, in the present invention, since a liquid crystal layer is generally thick at the transmissive region, it is preferably formed over the reflection electrode so as to use the thickness of the reflection layer and the insulating layer.

While the embodiment of the present invention has been described with regard to an amorphous silicon type thin film transistor liquid crystal display device, it may be applied to a polysilicon type thin film transistor liquid crystal display device.

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[Effect of the Invention]

10 In a reflective-transmissive complex type thin film transistor liquid crystal display device according to the present invention, a liquid crystal layer in a reflection region is different in thickness from a liquid crystal layer in a transmission region. Therefore, a phase of polarized light is controlled to increase the amount of emitted light in one region upon the state that the amount is fixed in another region and to enhance general screen luminance and contrast.

[Scope of the Claim]

5 [Claim 1]

A reflective-transmissive complex type thin film transistor liquid crystal display device comprising a reflection region where a reflection layer exists at a partial region in a pixel electrode of each pixel portion of a liquid crystal panel constituting a screen and a transmission region where a
10 transparent layer including a transparent electrode is formed,

wherein a liquid crystal layer in the transmission region is different in thickness from a liquid crystal layer in the reflection region.

[Claim 2]

15 The device of Claim 1, wherein a polarization plate and a phase difference plate whose pivots are perpendicular to each other are formed front and rear substrates in the liquid crystal panel, the thickness of the liquid crystal layer in the reflection region is set such that a phase shift of the light passing by liquid crystal is $\lambda/4$, and the thickness of the liquid
20 crystal layer in the transmission layer is $\lambda/2$ of the phase shift.

[Claim 3]

The device of Claim 2, wherein the thickness of the liquid crystal layer in the transmission region is two time larger than that of the liquid
25 crystal layer in the reflection region.

[Claim 4]

The device of Claim 1, wherein the transparent electrode in the transmission region is made of one selected from an indium oxide group.

[Claim 5]

The device of Claim 1, wherein an insulating layer formed between a thin film transistor drain electrode of the pixel portion and the reflection layer of the pixel electrode is made of photoresist transparent organic insulating material and is removed in the transmission region by means of the different thickness method.

[Claim 6]

The device of Claim 1 or Claim 5, wherein a metal layer made of a material having an etch selectivity with respect to the transparent electrode layer is formed under the drain electrode such that the drain electrode constitutes a part of the pixel electrode and includes the transmission region, the insulating layer where the contact region and the transmission region are removed is formed on the drain electrode, an aluminum-containing metal reflection layer for forming the reflection layer is stacked on the insulating layer and is patterned to expose the transmission region, and the transmission region of the metal layer is removed.

[Claim 7]

The device of Claim 1 or Claim 5, wherein a transmissive insulating layer is additionally formed on the transparent electrode layer under the drain electrode such that it constitute a part of the pixel electrode, the contact region and the transmission region on the drain electrode are removed to stack the insulating layer for making a window, and an aluminum-containing metal reflection layer for forming the reflection region is stacked on the insulating layer and is patterned to expose the transmission region.

[Claim 8]

The device of Claim 7, wherein the transmissive insulating layer is removed at the transmissive region.

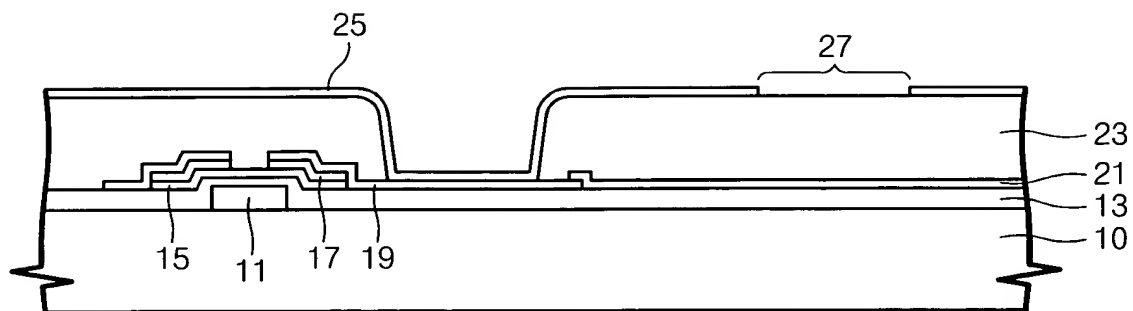
[Claim 9]

5 The device of Claim 1 or Claim 8, wherein the pixel electrode is formed on the insulating layer, includes a transparent electrode layer, an insulating layer, a reflection layer which are sequentially stacked, and is formed by removing at least reflection layer at the transmission region, in which the transparent electrode layer and the insulating layer are removed at
10 a part of the contact region disposed on a drain electrode of the thin film transistor and the reflection layer is formed thereon to be connected to the drain electrode.

[Claim 10]

15 The device of Claim 1 or Claim 8, wherein a fine concave-convex part is formed on the insulating layer to act as a condensing lens.

Fig. 1



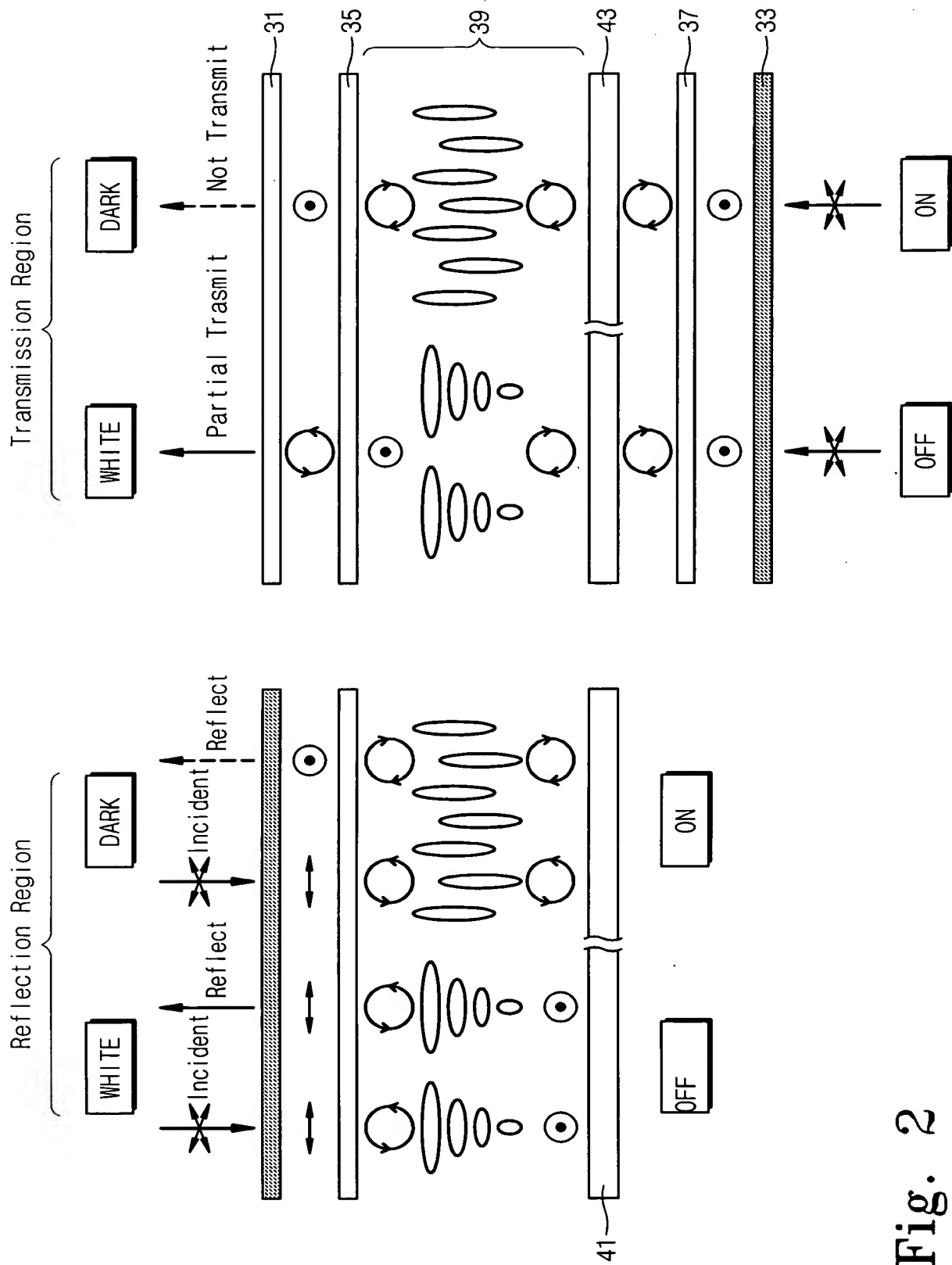


Fig. 2

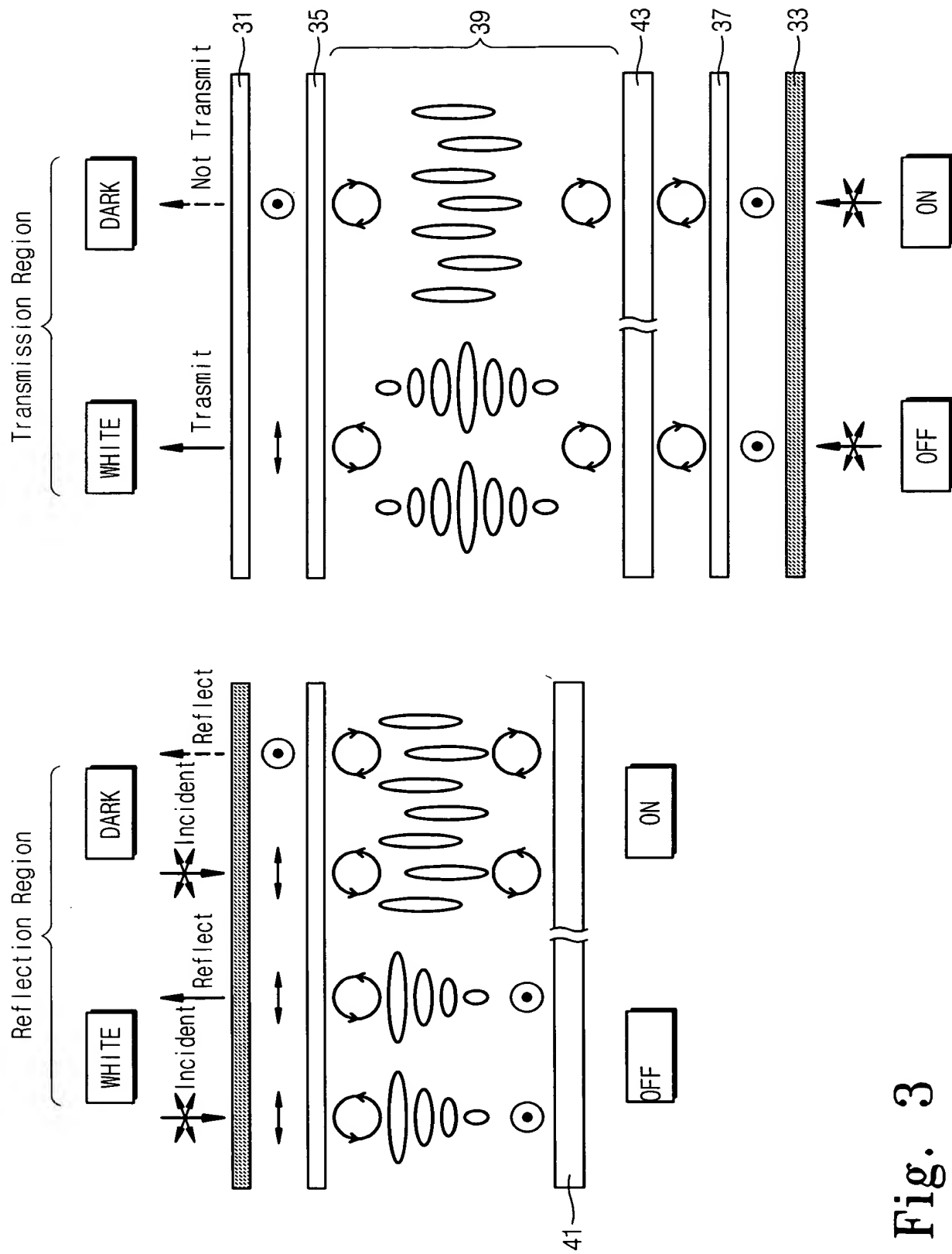


Fig. 3

Fig. 4

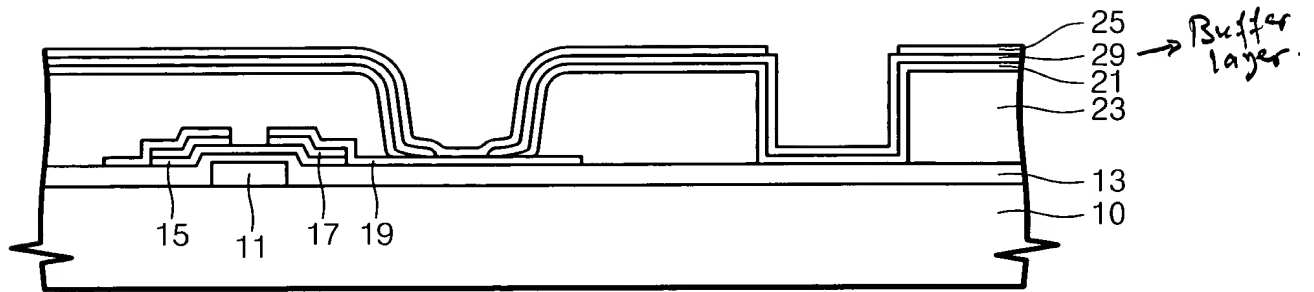


Fig. 5

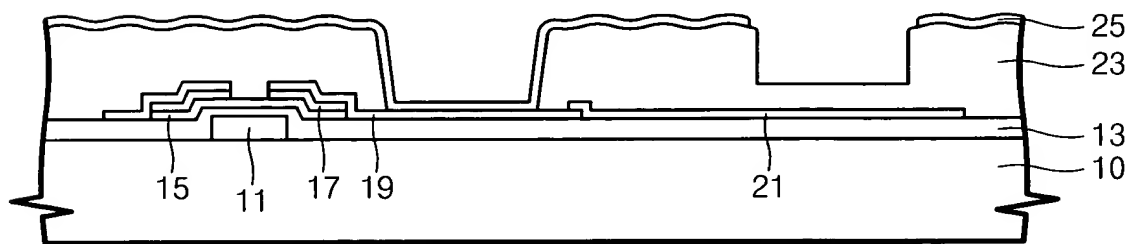


Fig. 6

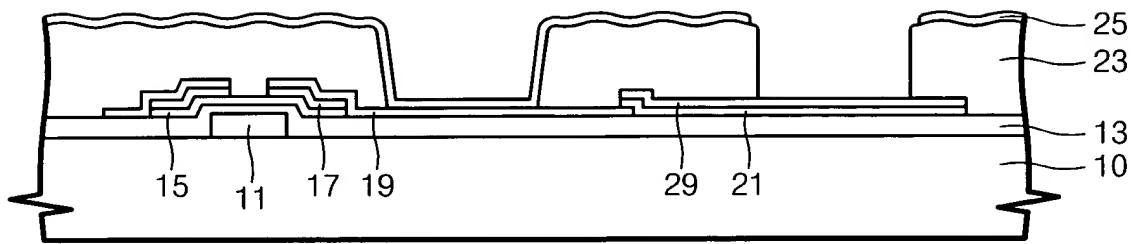


Fig. 7

